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ABSTRACT

This publication presents the activities pertaining to the third goal of this activity guide series. The activities in this publication focus on understanding conservation processes, efficiencies, socioeconomic costs, and personal decision-making. These materials are appropriate for middle school and junior high school students. These activities, organized by objective under the concepts listed, are interdisciplinary and can be used in many ways. The activities are simply ideas of things that students can do to help them understand the concepts. It remains for the teacher to choose and implement these ideas as desired. Activities range from stating the first and second laws of thermodynamics so the students' parents can understand them to designing a house which runs entirely on solar energy. (MR)

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CONVERSION of energy

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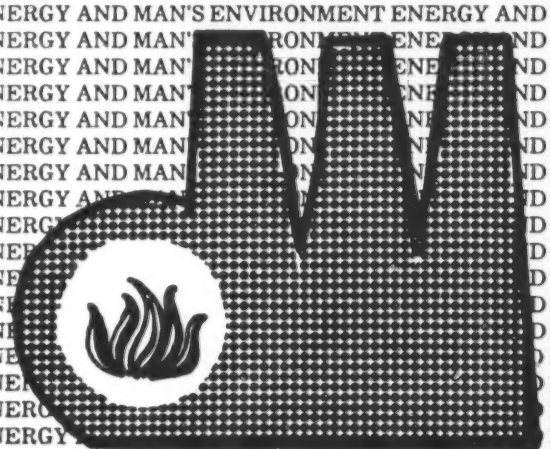

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ENERGY AND MAN'S ENVIRONMENT

Activity Guide

An Interdisciplinary Teacher's Guide to

Energy and Environmental Activities

Section Three

CONVERSION OF ENERGY

John Jones, D.Ed., Editor

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CONVERSION OF ENERGY

Introduction

There's no doubt that it is pleasant to stand by a roaring fire. Unfortunately it is not always convenient to warm oneself this way nor is it always convenient to cook over an open fire. Instead perhaps we would choose to warm water and circulate the hot water through radiators to heat our dwellings. Or we could build a fire in a woodstove and then cook on top of the stove. Energy conversion is a familiar thing to us; something with which we have daily contact. Our automobiles take the solar energy stored in fossil fuels as chemical energy and convert it to mechanical energy by combustion, which ultimately ends up as low-grade heat radiated back into space. Conversion of potential energy to the useful form is an essential part of energy use. Energy is the capacity to do work. In technological societies only a very small part of our work is done by direct human effort (chemical energy in food converted to mechanical energy by your body) because we have come to depend heavily on machines to ease our labors.

Energy conversion is governed by some very basic natural laws which have come to be called the Laws of Thermodynamics. The first of these laws states that energy cannot be created or destroyed, only its form changed; that is to say the total amount of energy in all its guises remains constant. Examples of various forms would include "kinetic energy" (motion), "potential energy" (gravity, elasticity), "chemical energy" (heat, nuclear energy, and the energy associated with mass itself - given explicitly by Einstein's famous formula, $E=mc^2$).

The Second Law states that natural spontaneous processes tend toward disorder and that concentrations of anything tend to disperse. That is; heat moves from a warmer to a cooler adjacent object until both are at the same temperature. While the First Law insists that the **amount** of energy in the universe remains constant, the Second Law demands that the fraction of energy **available** to be used is continually diminishing.

Efficiency is important to consider in the conversion of energy from one form to another. No process is 100% efficient; some non-usable low-grade heat is always produced at each conversion. For example, even the best modern coal-fired power plants are able to convert only 30-40% of the chemical energy contained in the coal into electricity. The internal combustion engine and present nuclear reactors are even less efficient. Food webs are excellent examples of energy conversions which move nutrients (food) through an ecosystem. Agricultural activities, what foods are eaten, and how they are packaged all require energy conversions whose overall efficiencies depend on their complexity. Succinctly put, the fewer conversion processes required in transporting and using energy, the greater the amount of energy that gets to its intended use. In practice, about half of the energy available to technological societies is dissipated as unused waste heat. Important decisions must be made in the areas of transportation, industrial production, heating, lighting and food production.

The activities in this section focus on understanding conversion processes, efficiencies, socioeconomic costs, and personal decision-making.

Dan Horn

EVALUATION

Conversion of Energy

The ENERGY and MAN'S ENVIRONMENT program actively seeks your ideas, comments, and general suggestions about this Activity Guide. If you feel there are ways this Activity Guide could be improved, or if more or different learning objectives or activities could be added, please let us hear from you. We plan to contact you in the near future to ask your opinion about the activities which you have used in your classroom. In anticipation of our request, we ask that you keep a careful record of all specific activities which are tried in your classroom. Please rate the effectiveness of each activity according to the following scale.

Chapter Title	Concept Number	Objective Letter	Activity Number	not at all useful 1 2 average 3 highly effective 4 5	Comment Suggestion
			EXAMPLE		
Sources	III	B	2	✓ (5)	students enjoyed very much
Sources	III	B	5	✓ (4)	students enjoyed very much
Uses	II	A	3	✓ (2)	too difficult for age level

EVALUATION Conversion of Energy

Chapter Title	Concept Number	Objective Letter	Activity Number	not at all useful 1 2 average 3 4 highly effective 5	Comment Suggestion

EVALUATION Conversion of Energy

Chapter Title	Concept Number	Objective Letter	Activity Number	not at all useful 1 2 average 3 4 highly effective 5	Comment Suggestion

EVALUATION Conversion of Energy

Chapter Title	Concept Number	Objective Letter	Activity Number	not at all useful 1 2 average 3 4 highly effective 5	Comment Suggestion

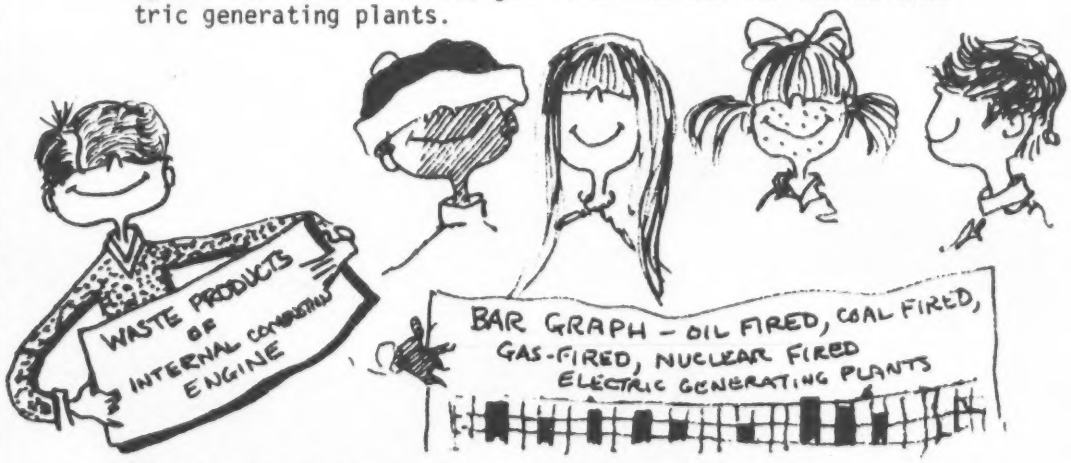
concept: I - There are natural and man-made energy conversion systems subject to natural laws.

conversion

objective: A - The student will be able to identify the relationship between the first and second laws of thermodynamics and conversions.

activities

1. State the first and second laws of thermodynamics so your parents will understand them.
2. Describe the waste products which come from the conversion of coal to "heat energy."
3. Describe the waste products from oil-fired, gas-fired, or nuclear-fueled electric generating plants.
4. Prepare a bar graph showing annual waste-product production by oil-fired, coal-fired, gas-fired and nuclear-fueled electric generating plants.


WASTE PRODUCTS OF INTERNAL COMBUSTION ENGINE
BAR GRAPH - OIL FIRED, COAL FIRED, GAS-FIRED, NUCLEAR FIRED ELECTRIC GENERATING PLANTS

5. Examine the wastes which result from various energy conversion processes. Measure the efficiency of different machines. Describe the waste produced by the internal-combustion engine.
6. Describe the waste products of the internal-combustion engine.
7. Compare "efficiency of conversion" of:

   1910 coal plant
   1970 coal plant
   1970 nuclear plant
   1970 MHD
   1960 hydro system

8. Illustrate the second law of thermodynamics by choreographing a dance using Flanders and Swann's recording of Thermodynamics.

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concept: I - There are natural and man-made energy conversion systems subject to natural laws.

conversion

objective: B - The student will be able to define a "natural energy conversion system."

activities

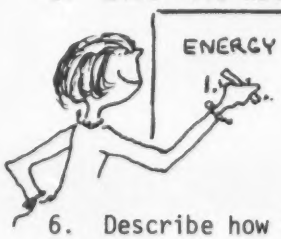
1. Using salt water, build an evaporation tank with a flat baking pan. Keep records of how long it takes the water to evaporate and how much salt is produced by this method.

2. Visit an art gallery and conduct an inventory of art objects which depict natural energy conversion. Explain the energy conversion being illustrated and attempt to hypothesize the original influence on the artist.

3. Observe a nest of young robins (chicks, sparrows, other birds) until they are feathered. What energy conversions have occurred?

4. Using an encyclopedia or a science book look up the electric eel. Explain to your class the energy conversions in his shocking behavior.

5. List five natural energy conversion systems.



6. Describe how the human body converts food to movement.

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concept: I - There are natural and man-made energy conversion systems subject to natural laws.

conversion

objective: C - The student will be able to define man-made conversion systems.

activities

1. Place a beaker or jar over a burning candle. Water will collect on the inside of the jar. Water vapor is a waste produced in any combustion process. Could there be a use for this vapor?

2. Describe the compressed hydrogen fuel cell, its benefits and its limitations.

3. Visit an art gallery and conduct an inventory of art objects which depict man-made energy conversion. Explain the energy conversion being illustrated and attempt to hypothesize the original influence on the artist.

4. Describe the solar cell, its benefits and its limitations.

5. Compare the energy conversion processes in fission and fusion reactors for the production of electrical power.

6. List five man-made energy conversion systems.

ART GALLERY

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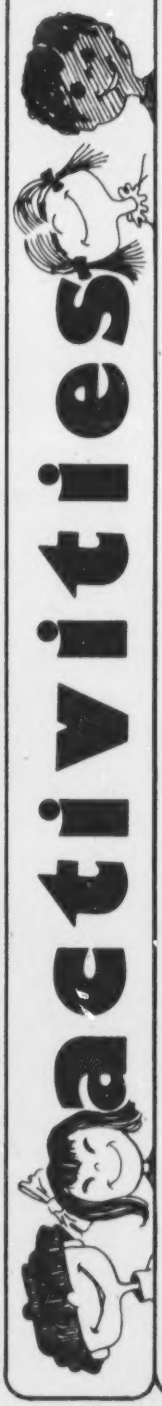
concept: I - There are natural and man-made energy conversion systems subject to natural laws.

conversion

objective: D - The student will compare the efficiency of natural and man-made energy conversion systems.



activities

1. Grow a plant in sunlight, dry the plant, weigh it and compare the weight with the weight of the original seed. Discuss solar energy and plant synthesis.

2. Burn wood splints with solar radiation. What type of energy is this? How does it work? How does it compare with other energy sources?

3. List examples of natural and man-made energy conversion.

4. Visit the kitchen of a restaurant or hotel and itemize the utensils or equipment that aid in the conversion of one form of energy to another. Design a utensil that will do the same work but which is not as wasteful as that of the restaurant.

5. Compare the efficiency (net calorie, BTU or other measure) of tilling, planting, fertilizing, harvesting, storing, feeding, grazing, slaughtering, processing, transporting and cooking beef.

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concept: I - There are natural and man-made energy conversion systems subject to natural laws.

conversion

objective: E - The student will identify several man-made types of energy conversion.

activities

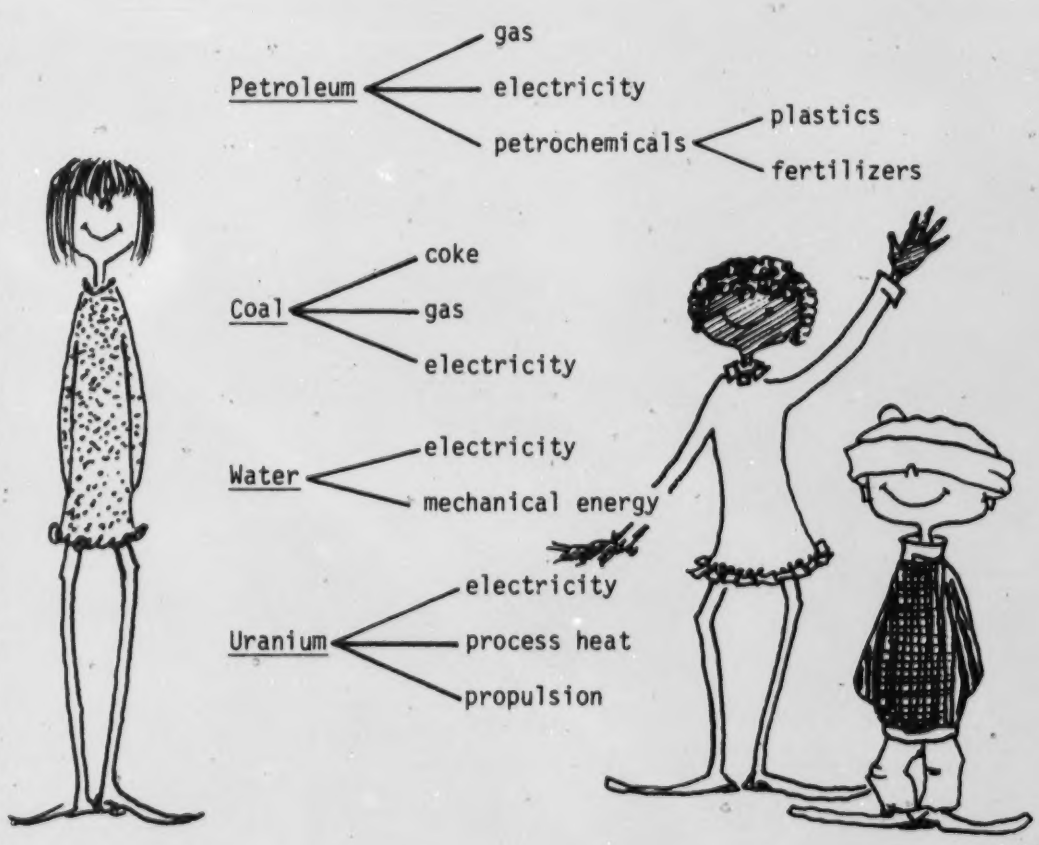
1. Attempt to construct a world in which photosynthesis did not exist. Use everything available under these new conditions. Assume that man has found a way to sustain himself.

   From this model recreate a city. List the energy sources we use that have come from photosynthesis.

2. Visit a coal powered electrical plant and observe the conversion process.

3. Given the energy sources listed below depict those processes necessary to convert these sources to other products.

   Source:



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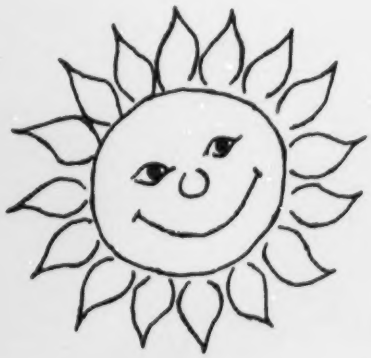
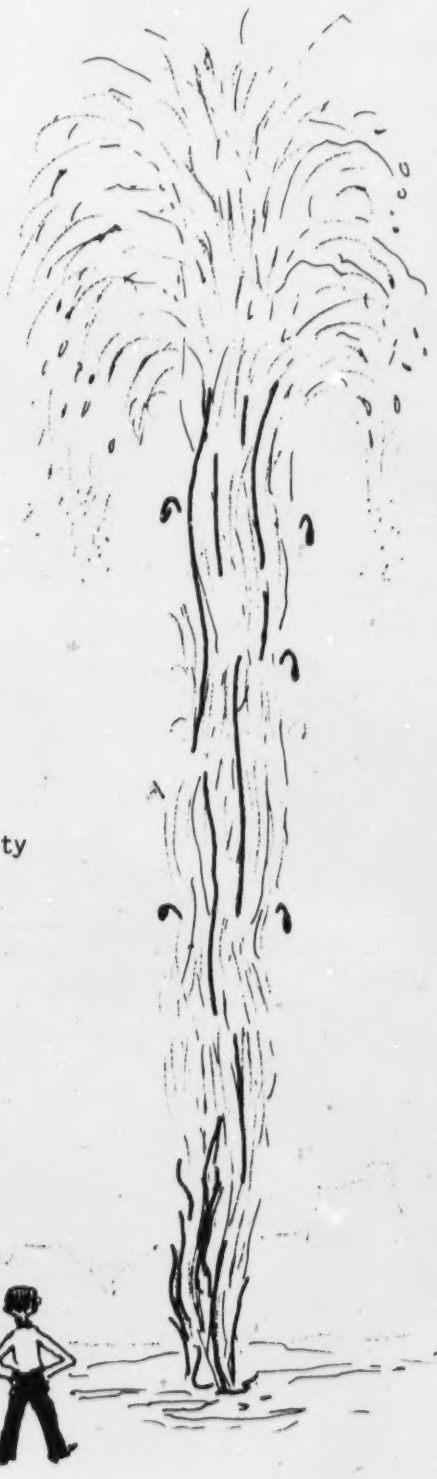
activities

Concept I
Objective E



Solar — heat; electricity; photosynthesis

Geothermal — heat; electricity



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concept: I - There are natural and man-made energy conversion systems subject to natural laws.

conversion

objective: F - The student will support the statement that "The waste products from a man-made energy conversion system are more difficult for the natural environment to accommodate than waste from natural energy conversion systems."

activities

1. Compare the effects of dumping old oil from a car into a meadow with the effects of dumping the waste products from a few horses.

   Take two garden plots (potential garden plots) and compare their productivity, using manure on one and oil on the other.

2. Ask the Highway Department which types of plants are resistant to exhaust emissions from cars and trucks. If possible, photograph vegetation along a busy highway with natural plantings exposed to extensive emissions. Compare these with photographs of vegetation in a swamp exposed to emissions of methane (swamp gas).

3. Using a Hatch kit to measure dissolved oxygen take measurements of O_2 content of the water 100 ft. upstream from a sewage outfall, 100 ft. below the sewage outfall, and a mile downstream from the same sewage outfall.

4. If possible use similar testing measure above and below a plant releasing chemical effluents into a stream.

5. Observe and collect various solid particles found in the air.

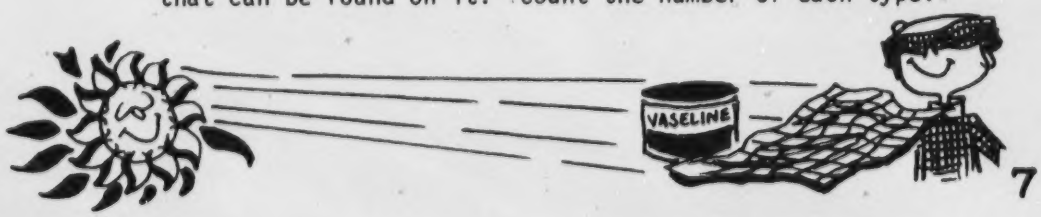
   Materials: 2½" square waxed paper, pencil, ruler, board, thumbtacks, vaseline, hand lens or microscope, paper.

   Procedure:

   a. Mark the waxed paper into ½" squares. Attach the paper to a board with thumbtacks. Smear the paper evenly with vaseline.

   b. Select an open place in your backyard where paper can remain undisturbed for at least a week.

   c. At the end of the time examine the materials which stick to the vaseline with a hand lens or microscope. Choose one square and count the number of different types of materials that can be found on it. Count the number of each type.



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Concept I
Objective F

d. Select the other squares and compare types and amounts found on them. Organize this information into chart or graph form.

Question: Which of these materials are nature made?

Which of these materials are man-made?

Which are more deleterious to the environment and why?

6. Visit a secondary treatment plant where the operator will explain both mechanical and biological purification methods.

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concept: II - All conversion processes use energy or lose heat energy.

conversion

objective: A - The student will describe the transfer of energy in living systems.

activities

1. Set up a balanced (closed) aquarium and observe how the energy is transformed and converted from one source to another.

2. Observe the nitrogen fixing nodules on clover plants and trace the transfer of the nitrogen through the biosystem.

3. Using pictures cut from magazines or original drawings, make posters diagramming a food web. If adequate materials are available specify that webs be from different environments: pond, desert, grassland, coniferous forest, etc.

4. Using the posters or diagrams of a food web, explain why there are more mice than moose, either in number or in mass. Note: Either a biomass pyramid or an energy pyramid diagram will be useful here.

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concept: II - All conversion processes use energy or lose heat energy.

conversion

objective: B - The student will be aware that no conversion process is completely efficient. The price of conversion from a less usable to a more usable form is always waste heat. (e.g. chemical energy in oil to mechanical energy in an engine).

activities

1. Affix a thermometer to the exhaust of a car prior to the car being started. Read the thermometer. Start the car and run it for several minutes. Have the thermometer read again and temperature recorded. What is one form of waste resulting from this conversion?

2. If a school compost pile is available take its temperature with a thermometer 4 or 5 inches under the surface. (If no compost pile is available at school ask individual students who have them available at home to check on the temperature of theirs.) At the same time have a student take the air temperature at the edge of the pile. What energy conversions are occurring in the compost? What waste product(s) are formed?

3. The Finger-Tingler: If your hands are hot are you cold hearted? Have all the children touch an unlighted incandescent bulb to note it is at room temperature. Have several children put two or three fingers on the bulb simultaneously, holding them there while it is lighted. See how quickly it gets warm. (Teacher is the watch dog.)

4. Read a thermometer which is lying on a table underneath a gooseneck lamp (or some other source of incandescent light). Turn on the light 12" from the thermometer. Read the thermometer and post readings on the board every three minutes until the temperature reaches a plateau. Time vs. temperature could be graphed.

5. Something to think about:

   Think about burning a gallon of oil in a little lamp like an oil lamp. How long would it burn? Could you warm your hands by it all that time?

   If that same gallon of oil were burned in the furnace of a house, how much heat would be added to the house? Why the difference?

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concept: II - All conversion processes use energy or lose heat energy.

conversion

objective: C - The student will be able to list the ways energy is used to exploit various energy sources.

activities

1. Find pictures which illustrate the exploitation of each of the following: coal, oil, wood, uranium.

   Paste them to a large mural. Discuss those energies used to exploit each source. Find or draw pictures to illustrate these energies.

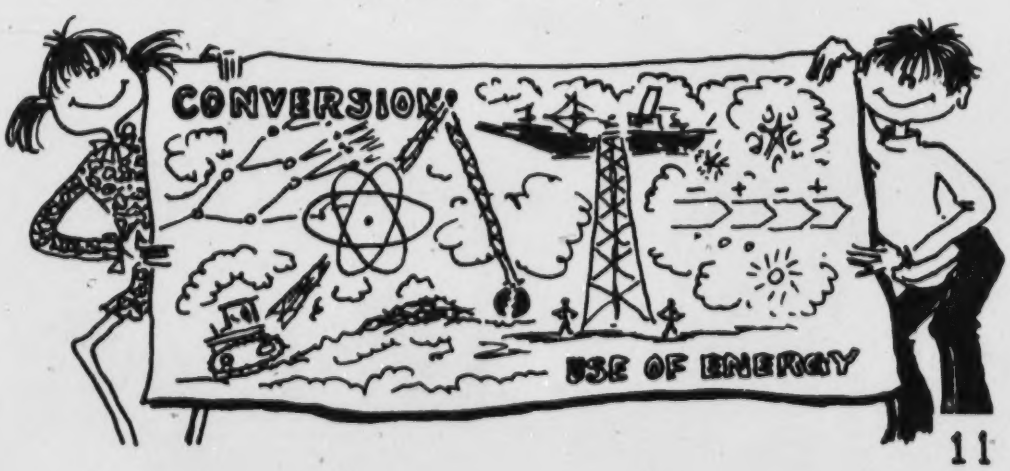
2. A candle, a Coleman lantern, or a fireplace fire is each a source of heat and light. Can you get these energies from them without using any energy? How much energy went into making the candle, the lantern, the lantern fuel, or into chopping the wood?

3. Look up the energy requirements for firing up a coal or oil powered generator or a nuclear powered reactor. Compare this with the electrical output of the generating plant.

4. Try to list all the energy-using processes needed to produce electricity in a local utility plant. Start with energy used to construct the plant and energy used to extract the fuel from its source.

5. An energy source which seems to grow greater as it is used is the plutonium used as a fuel in a reactor. How does this fit in with the laws of thermodynamics?

   Investigate this paradox. For further information about uranium mining and processing or the nuclear fuel cycle write to: Trojan Visitors Center, Route 2, Box 120, Rainier, Oregon 97048, or your nearest nuclear facility.



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concept: II - All conversion processes use energy or lose heat energy.

conversion

objective: D - The student should be able to identify by-products resulting from energy conversion.

activities

1. Place a piece of filter paper in the exhaust stream of an automobile for several minutes; then inspect the filter for deposits. Caution: CO is dangerous.

2. Observe that incomplete burning in a heating installation contributes to air pollution. Close the air holes of the burner to produce a luminous flame. Using the metal clamps, hold the bottom of the dish in the flame. What happens to the dish? Why did it turn black? (Incomplete burning of hydrocarbons causes soot to form.)

   Change the flame to non-luminous and put the sooty portion of the dish above the hottest part of the flame. What happened to the soot? (Carbon is burned off.)

   Try to visit a fuel installation to let students observe the combustion of fuels containing carbon. Discuss with them the black smoke they often see billowing out of industrial smoke stacks. What effect does this have on the community?

3. Observe that various chimneys from houses, factories, etc. contribute by-products in the form of smoke.

   Observe as many of the chimneys on factories, hospitals, homes, apartments, and other buildings as you can. Look for and record information on each.

   Observe each chimney at different times for a period of one week. Which chimney produced the most smoke at one time? Which chimney produced the thickest smoke at one time? How did wind affect the smoke cloud? How would the number of chimneys affect air pollution?

   The children might want to collect pictures showing smoke coming from various chimneys.

4. Place a shiny metal object in a candle flame. What is the deposit that appears on the metal? Where does it come from? Could there be a use for it?

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Concept II
Objective D

5. Bubble exhaust gases through lime water to determine if carbon dioxide is present. Caution: CO is dangerous.

   Bubble exhaust gases through water and test with pH paper to determine if acid-forming substances are present in the exhaust.

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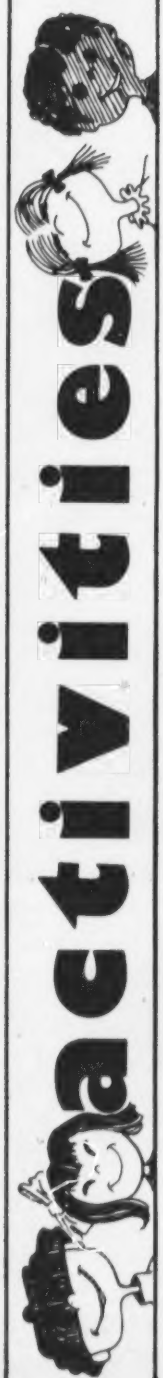
concept: III - "Direct" energy use is more efficient than converted energy use but converted energy is more versatile.

conversion

objective: A - The student will be able to describe the earth's heat budget.



activities

1. Find out how much of the solar energy reaching a square meter of the earth's surface is absorbed and how much is reflected.

   Of that which is absorbed, how much is taken in by plants and how much is taken in as heat by the ground or buildings?

   Does Mother Earth make efficient use of the energy delivered to her?

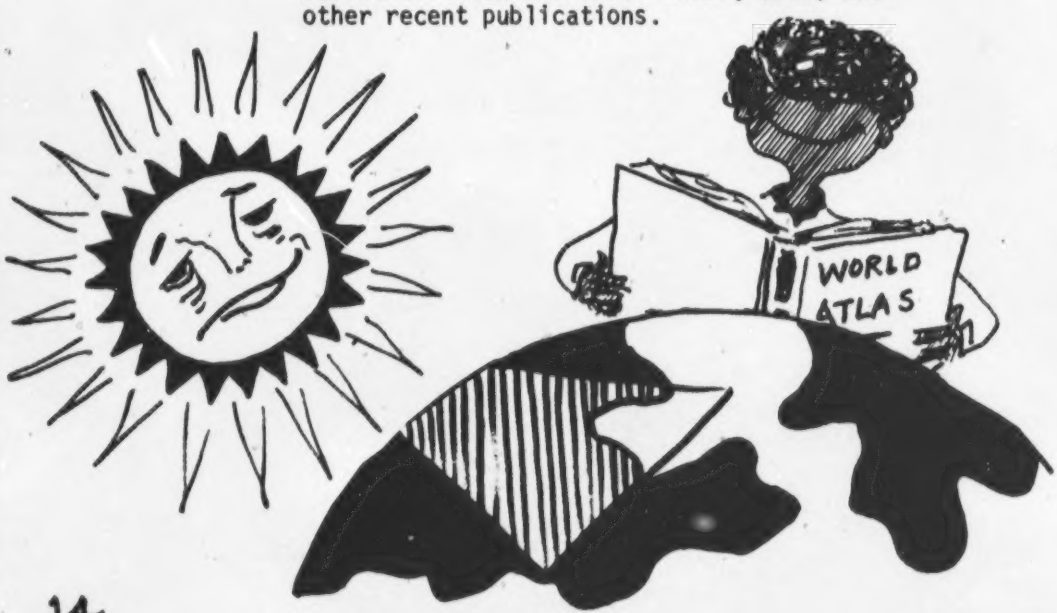
2. How does the earth's heat budget determine weather?

3. In what ways are the different world climates dependent on the heat budget? (Remember, budget includes both income and outflow.)

4. How does the earth's heat budget make earth an appropriate site for life? What are physical limits or parameters for life as we know it? As an extension, find out if there are other planets in the universe which could support life.

   Footnote 1: How could we recognize "life" if it existed in some form altogether unknown to us?

   Footnote 2: See The Galactic Club, Author - Publisher: Stanford Univ. Press, 1974, and other recent publications.



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concept: III - "Direct" energy use is more efficient than converted energy use but converted energy is more versatile.

conversion

objective: B - The student will be able to determine the major factors which limit amount of solar energy reaching and being reflected from the earth.

activities

1. Determine that smoke reduces the amount of sunlight in an area.

   Put the incense sticks in the aquarium and light them. Hold the flashlight behind the aquarium; aim the light at the meter and record the reading. What happens to the reading as the amount of smoke increases? What happens to a city when pollution prevents sunlight from passing through?

2. Observe that incomplete conversion results in smog.

   Turn two flasks upside down and fill only one of them with smoke (use incense or some other simple method). Following the smoke, immediately add a stream of live steam into the flasks. What happens in both containers? Same results? (In the clean flask the moisture should condense and run down the sides of the container; the smoked flask should be filled with a dense fog.)

   What caused the fog? (Dust particles form the nuclei to help water droplets condense to form fog.) What does the word "smog" mean? (Smoke + Fog = Smog). What effect might this weather condition have on the environment? What effect does this have on the sunlight reaching the earth and the amount of heat reflected back by the earth?

3. Suggest that students enter a car which has been sitting in the sunshine with doors and windows closed, noting the temperature difference between the car's interior and the surrounding air.

   Have them look up the phrase "hothouse effect". In what ways does the car demonstrate the hothouse effect?

4. Using an atlas find the areas of the earth with the greatest number of sunny days/year. How do the people living in these areas live? Since they have immense amounts of solar energy (sunshine + heat), do they have immense amounts of usable energy? Explain.

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concept: III - "Direct" energy use is more efficient than converted energy use but converted energy is more versatile.

conversion

objective: C - The student will be able to identify examples of "direct energy" uses.

activities

1. Define "direct energy" use.
2. Stand in the sun. Now describe what you feel, its source, and determine if the heat is converted or is a direct use.
3. Construct a kite and fly it. What is the energy source? Is there any conversion in this form before it is used?
4. Construct a pin wheel. Take the pin wheel outside and determine the source which powers it and if it is direct energy or indirect.

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concept: III - "Direct" energy use is more efficient than converted energy use but converted energy is more versatile.

conversion

objective: D - The student will be able to describe examples of indirect energy conversion situations that work for man.

activities

1. Construct a list of energy conversions in order of their utility for society and defend that order.

2. Using a recipe for cooking jam with only solar energy, determine the "cooking" time for a typical summer day in Seattle, Spokane, Portland or Albuquerque.

3. Go on a "field walk" with a small group of other students and list all the energy conversions you see. Do it in this manner:

Object Viewed	Energy Source	Ultimate Product
Automobile	Gasoline	Motion
Light Bulb	Electricity	Light
Sailboat	Wind	Motion

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concept: IV - There is a variety of units of measure for the efficiency of energy conversion.

conversion

objective: A - The student will compare the energy output of a conversion system to the energy content of the energy source and note the unit of measure for each.

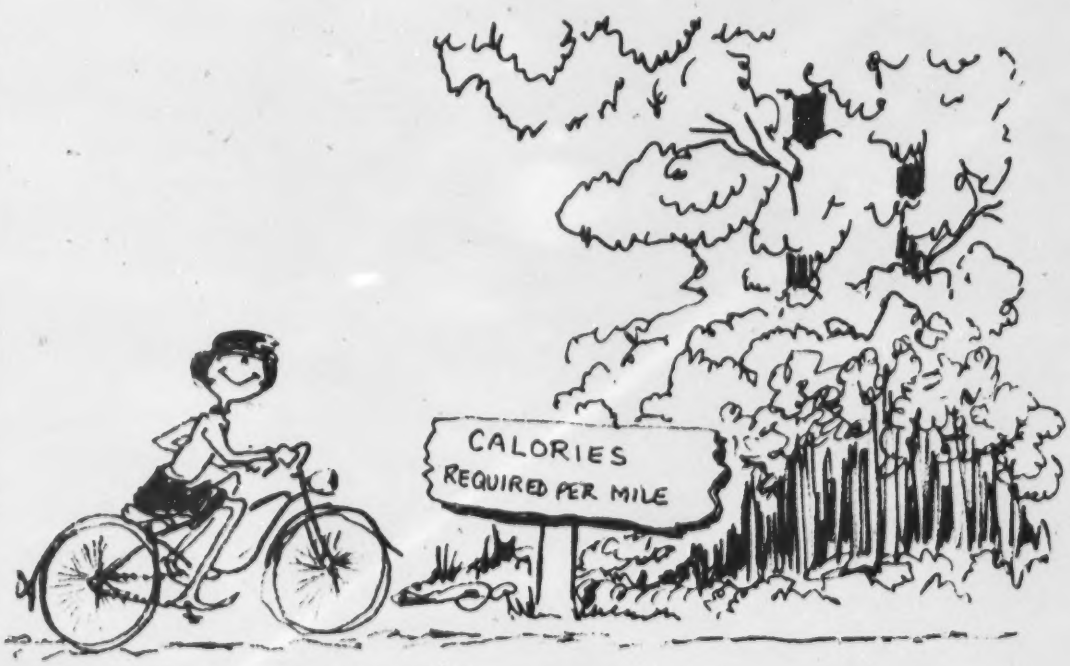
activities

1. Conduct activities with a transformer to see how voltage and amperage may be changed. Meters are needed. The Intermediate Science Curriculum Study has suggested exercises for Level I (7th grade). Danon Scientific makes the relatively inexpensive meters.

2. If you need 1,000,000 BTU's of heat, how many kilowatt hours, barrels of oil, cubic feet of natural gas, tons of Montana coal, or grams of uranium will be required?

3. Research the literature and report the advantages and disadvantages of powering an automobile with propane instead of gasoline. Note should be made of operating cost per mile, emissions (pollution), performance and convenience.

4. Determine how many calories it requires to ride a bicycle one mile and see which food sources would provide you with the most calories, per unit of measure, to complete this task.



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concept: IV - There is a variety of units of measure for the efficiency of energy conversion.

conversion

objective: B - The student will identify at least seven units of measure to be used in comparing energy sources and the results of conversion.

activities

1. If you have a 10 horsepower electric motor, how many kilowatts of electric capacity must be available to operate it?

2. A Chicago company is comparing the practicality of using Montana coal or West Virginia coal. What, besides delivery time, are the four things they would compare and in what units of measure?

3. How many _____ of oil does it take to equal 1,000,000 cubic _____ of natural gas (which is also called a _____) and how do you convert it to _____ _____ (BTU's)?

4. List at least five units of measure and give a conversion in which each unit would be used to measure the resulting product.

5. Given a conversion table the student will demonstrate his ability to change one unit of measure to another.

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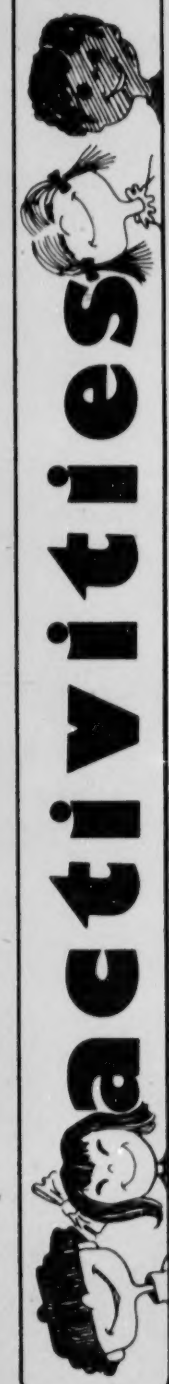
concept: V - Energy "costs" are partly related to the efficiency of energy conversions and transport.

conversion

objective: A - The student will explain why electricity costs less to produce from some sources than from others.

activities



1. What economic, environmental and other factors encourage the use of liquefied natural gas in Japan? Why is it not imported to other large energy-using countries?

2. To determine whether an energy conversion process is converting one form of energy to another, the term "efficiency" is used. Determine a formula or rule that could be used to find out if a particular process will be "efficient" or not. How would you know whether one process will be more efficient than another?

3. Request permission from a local power utility to visit its switchyard and substations. Have a utility representative explain the function of the switches, capacitators, breakers, transformers and insulators. Find out from him and from the library how much power is lost in transmission and why.

4. Describe the conversion and transport process from source to consumer when electricity is the product. Include the loss of electric power during transmission and propose alternatives for using the original energy source more efficiently.

5. Make a list of the relative costs of energy transported by different means. Compare it with a printed table of such information.

   Calculate differences if changes were made. Calculate possible pollution "costs" and try to come up with solutions. Calculate possible savings to the community.

6. Take a field trip through a housing development where the utility (electric, telephone, cable-television) lines are buried and then to one where the lines are strung overhead on poles.

   Discuss the following:

   a. Which method of energy distribution is more appealing and why? Draw a picture of each. Draw a picture of a neighborhood as it would look without the poles that are there now.

   b. Which method would cost more to install initially?

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Concept V
Objective A

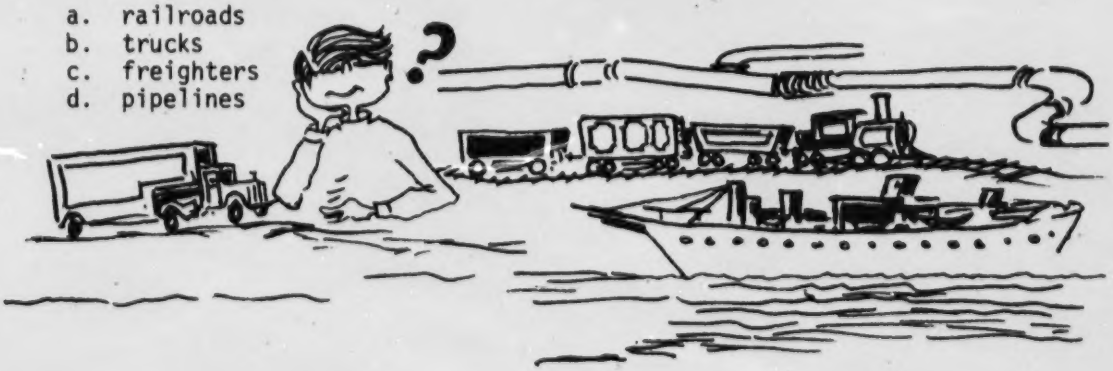
c. To what extent would the student prefer to pay more for a more appealing environment?

d. Find out how much it would cost per house to bury utility lines in areas where they are presently on poles.

7. Research and prepare presentations for each of the roles presented below:

You are a large distributor of oil in a metropolitan area. You are located in an area accessible to the transportation facilities listed below. You wish to transport the oil to your distribution plant with maximum efficiency and the least adverse effects on the environment. Representatives from the following transportation facilities present their "sales pitch" to you and your directors:

a. railroads
b. trucks
c. freighters
d. pipelines



Which means will you choose and why?

8. Assume a perfect fuel would:

_____ be unlimited in supply
_____ be equally distributed throughout the world
_____ present no technological problems
_____ be highly efficient
_____ present no aesthetic problems
_____ have no adverse impact on the environment

Select the fuel you feel is the most nearly perfect fuel and defend this choice. If another class member selects a different fuel, discuss the matter with that student.

9. Construct a list of methods of transporting energy-producing substances, presenting them in order of their utility for society, and defend that order.

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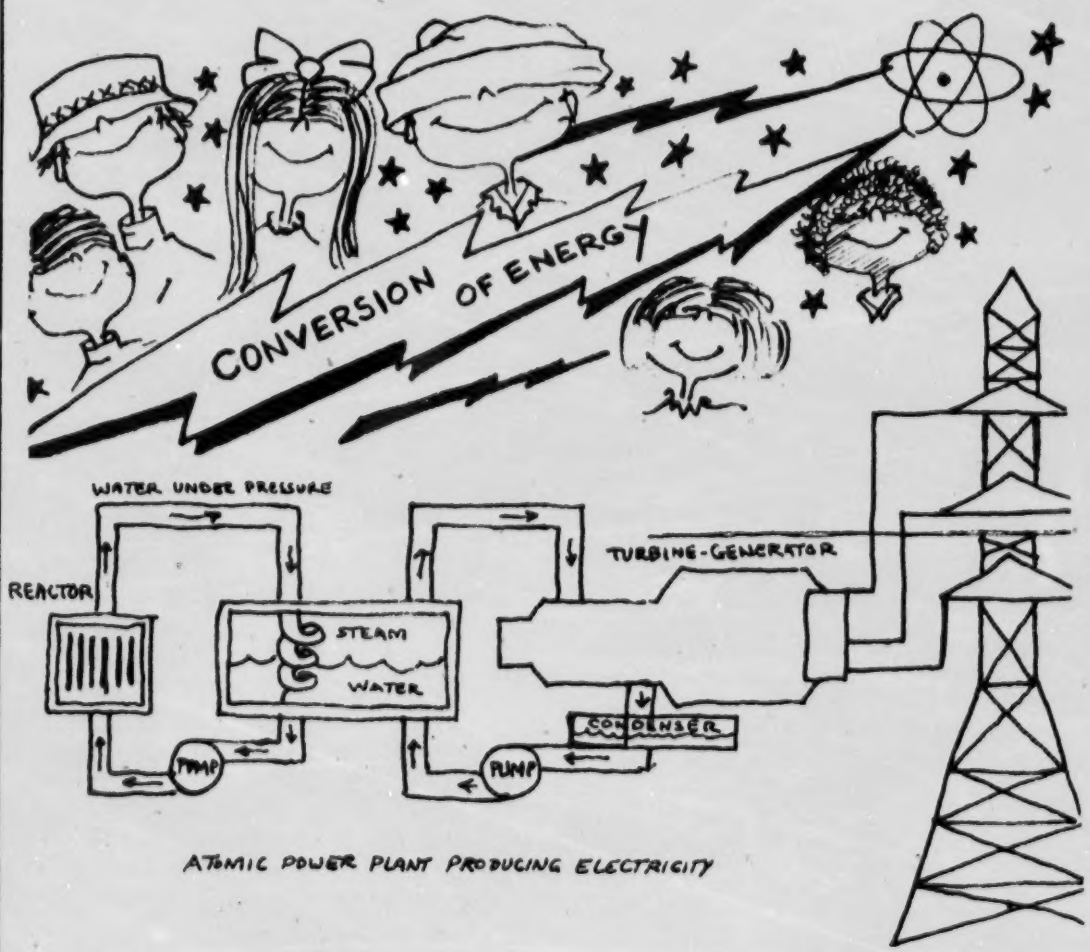
concept: V - Energy "costs" are partly related to the efficiency of energy conversions and transport.

conversion

objective: B - The student will compare published efficiencies of conversion costs of conventional nuclear and fossil steam electric plants with proposed magnetohydrodynamics system.

activities

1. Prepare a simplified drawing of the basic magnetohydrodynamic (MHD) system and explain its operating theory.
2. Draw a bar graph to illustrate and compare the efficiencies of conventional electric steam generating plants fueled by natural gas, coal, oil and uranium with an MHD plant.
3. Based on currently available fuel cost statistics, compare the cost of electricity from the plants of the above.



ATOMIC POWER PLANT PRODUCING ELECTRICITY

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concept: V - Energy "costs" are partly related to the efficiency of energy conversions and transport.

conversion

objective: C - The student will be able to evaluate the costs related to the efficiency of different energy conversions.

activities

1. List the factor that will influence the dollar costs of converting oil, coal and natural gas to electricity if the converting plant is located in your city.

2. On a regional map locate the nearest source of bulk oil, coal and natural gas. Compare the total costs of bringing the fuel to an electric generating plant in your city against the costs of generating the electricity at the mine or bulk delivery points and using transmission lines to deliver the electricity.

3. In Activity 2 what other "costs" or considerations might influence the decision of plant location?

4. Compare the "plant efficiency rating" to convert oil, coal, uranium and falling water (hydro) to electricity.

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concept: V - Energy "costs" are partly related to the efficiency of energy conversions and transport.

conversion

objective: D - The student will be able to compare the conversion costs of energy forms to their competitive economic relationship.

activities

1. Photograph areas of your community with underground wiring and areas of the community with overhead wiring.

   Interview residents in each area to find out what "dollar value" they would place on the aesthetic advantages of underground wiring. Then find out if this "dollar value" is close to the actual cost per household for underground wiring.

   How is the cost of underground wiring met in a new subdivision?

   Ask the power company to state advantages and disadvantages of underground and overhead wiring. See what can be added to that list.

2. Visit a "power corridor": transmission-line corridor, gas-pipeline corridor, oil-pipeline corridor, highway corridor. Discuss the advantages and disadvantages of lumping them together in one corridor.

3. Make a bar graph comparing three regional methods of generating electricity. Each bar will be segmented to show cost of fuel, transportation, if any, conversion cost and transmission cost.

4. Assume that it requires 25,000,000 BTU's to heat your home for one year. Compare the cost of heating with three locally available fuels.

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concept: V - Energy "costs" are partly related to the efficiency of energy conversions and transport.

conversion

objective: E - The student will identify reasons why energy costs more at the point of delivery to the customer than it did at the point of origin.

activities

1. Collect material from newspapers, files, magazines and testimony before congressional committees about the controversy over the method of delivering oil from the Alaskan oil fields. Debate the merits of suggested methods.

2. Secure a one-line diagram from a local utility. Trace the path the energy flows from its source of generation to the supplier or substation which supplies your home or school. Are there ways in which this route could be improved?

3. Select a major energy source and examine the transportation of that energy by visiting the actual sites of such transmission. Determine the costs (environmental, economic, resource use and waste) of the transmission and compare findings with those of other members of the class.

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concept: VI - There are ethical, legal, aesthetic, social, political, economic, biological and physical benefits and problems associated with energy conversion.

conversion

objective: A - The student will describe the legal, physical and aesthetic problems resulting from the construction of energy conversion plants.

activities

1. Pretend that four groups of people are going to set up housekeeping beside a common stream; their land is contiguous. They will generate their own energy. Group 1 will set up a coal-fired generating plant; Group 2 will set up a gas-fired generating plant; Group 3 will set up a nuclear-fueled generating plant; Group 4 will set up a hydro-powered generating plant. Join one of these groups.

   Each group may oppose the erection of any other group's plant on the basis of pollutants, passage of fuel across their territory, use/abuse of a common resource such as air or water.

   Defend the plant of one group, but eventually decide the best possible method of generating electricity, whether it should be a common source or several generators and which one. If a common source is selected, whose land will it occupy and what compensation will be provided for the land use?

2. Pretend that you are the Secretary of the Interior and must decide on the best location for an oil pipeline from Bellingham to the rest of the state. Locate the line and defend the choice aesthetically, environmentally, economically, politically.

3. List the energy conversion and transfer processes; contrast the aesthetic and utilitarian advantages of each.

4. To convert energy from coal to steam to electric energy, some type of facility or plant must be constructed. From a series of pictures (take them with a camera or clip them from electrical trade journals) prepare a bulletin board which illustrates plants which are more attractive and those which are not. In a discussion, point out features of the more attractive plants.

5. Construct a priority list of energy conversions in order from aesthetically less pleasing to aesthetically more pleasing.

6. Pretend your neighborhood is to have a fuel-fired electric plant installed. The kind of plant has not yet been determined but a hearing has been scheduled by the city council and planning commission. Research the problem.

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Concept VI
Objective A

6. (Continued):

Choose one of the roles listed below and act out such a hearing:

Mayor
Council members
Representatives of each type of fuel-fired plant
Citizens for and against each kind of plant

DEVELOPING A SIMULATION GAME:

Identify the problem or issue to be decided upon.

Identify the choices available to the decision makers.

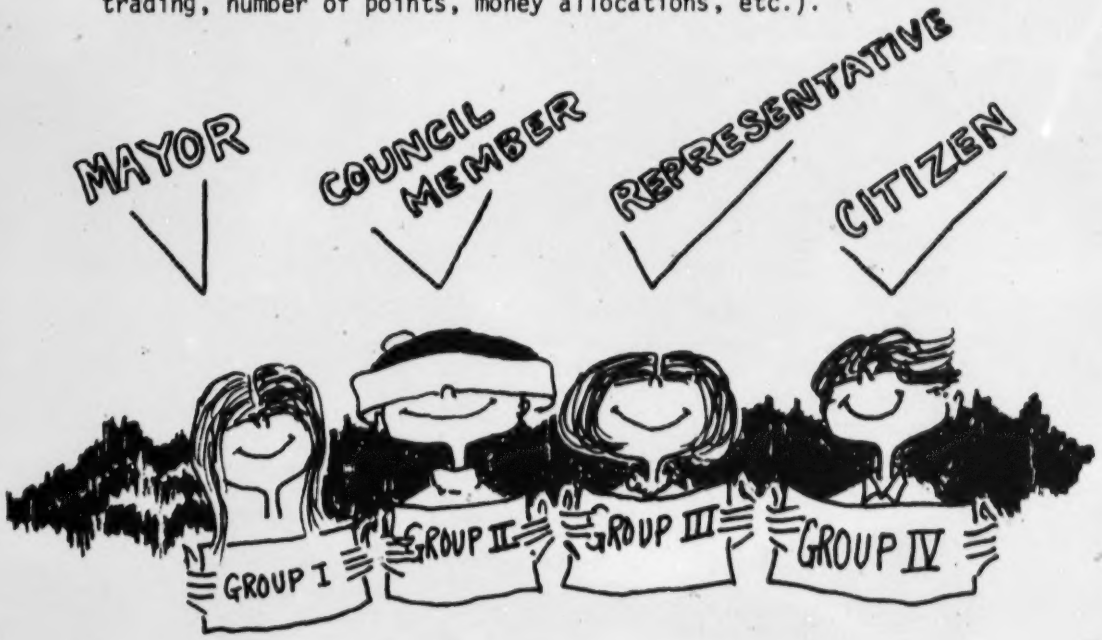
Identify the factors having an influence on the decision.

Identify individual or group roles.

Identify the factors (for or against) assigned to each role.

Establish conditions for the players (i.e., resources, voting procedures, bargaining money, etc.).

Include limits or rules for what is permissable behavior (time factor, trading, number of points, money allocations, etc.).



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concept: VI - There are ethical, legal, aesthetic, social, political, economic, biological and physical benefits and problems associated with energy conversion.

conversion

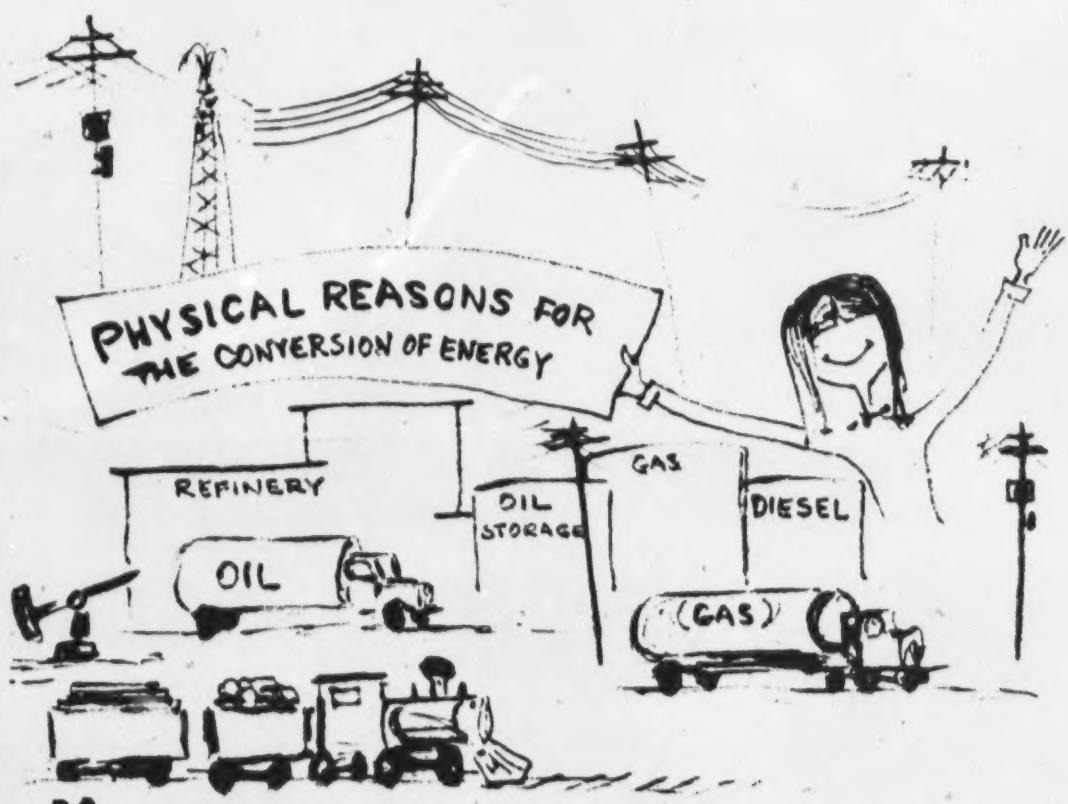
objective: B - The student will describe the physical reasons for the conversion of energy.

activities

1. List six different ways to move people or goods. List six different fuels that may be used. Discuss the reasons why all fuels cannot be used in all six applications.

2. Using the six fuels listed above, list those which can supply total energy to your home, separately list those that can supply a portion of the energy requirements and finally, those which are of no use in your home.

3. Automobiles have been built to operate using gasoline, diesel oil, liquefied natural gas (LNG) or liquefied petroleum gas (LPG) (Propane) and electricity. List the advantages and disadvantages of using the stated fuels by tracing each from the source to refining or conversion to your locality. Are the advantages and disadvantages reflected in the price?



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concept: VI - There are ethical, legal, aesthetic, social, political, economic, biological and physical benefits and problems associated with energy conversion.

conversion

objective: C - The student will identify some of the biological problems arising from the conversion of energy.

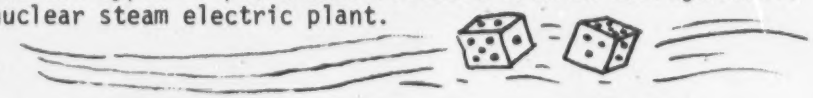
activities

1. List and evaluate the positive and negative counter-balance of various energy source uses (i.e. fossil fuel versus nuclear fuel, electric plants).

2. List the possible effects of marine life in 50^{o}F fresh water river if 2% of the river water is used in the condenser of a steam plant and returns to the river at 70^{o}F.

3. Compare the types of pollutants released from an average fossil and nuclear steam electric plant.

4. GAME:



This game consists of starting each player with $100,000 of play money. By rolling dice they have turns in the sequence of low to high numbers. There are stacks of cards representing:

a. Utilities with different types of energy sources.
b. Raw materials - petroleum, coal, uranium, etc.
c. Manufacturing and transportation companies which use energy.
d. Consumer's demands for various products from (c) above.

Consumer cards show market's demands for each of (c) above. The goal is to make more money. Each player in turn has the choice of buying the upturned card on each stack from 1-3 or skipping the opportunity. Those who have cards of raw materials and utilities will make conservative fixed amounts of money by selling to other players. Those who are in manufacturing or transportation will make much or little money depending on uncertainty of card turned up in demand pile (d).

The turns are taken in sequence; luck depends on shuffled sequence of consumers' demands.

There is an advantage to owning raw material and related utility and related manufacturing.

The profit is kept by same player.

If certain consumptions of raw materials reach fixed amounts, all players must pay the "bank" for pollution.

Special pollution piles against specific industries or transportation neglects will be made once each to add pollution control devices. These cards will be scattered among consumer cards.

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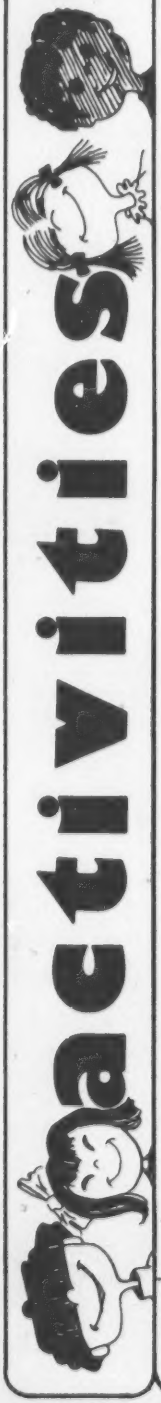
concept: VI - There are ethical, legal, aesthetic, social, political, economic, biological and physical benefits and problems associated with energy conversion.

conversion

objective: D - The student will identify ways that energy conversions for utilities benefit a community.



activities

1. Draw a diagram of a hydroelectric facility (including the dam and lake). Research the benefits (other than jobs directly related to this industry) which have arisen due to the construction of this facility:

   recreation facilities; jobs related to the recreation; road building; etc.

2. List all those objects which operate on electrical power in your home and then describe in what ways your life would be changed if this form of power were not available.

3. Contact the regional public gas company and acquire information showing the benefits this utility provides to the community.

4. Research communities in which garbage is "recycled" and show the resulting benefits to that community.

5. Visit an area where raw sewage is dumped into a body of water and photograph the effects of this procedure. Now visit an area where the sewage is processed before disposal and photograph the effects shown here.

   Compare the two processes to see benefits of conversion.

   If visiting these areas is not possible, students can get contrasting pictures from current publications.

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concept: VI - There are ethical, legal, aesthetic, social, political, economic, biological and physical benefits and problems associated with energy conversion.

conversion

objective: E - The student will be aware that there are problems arising from the disposal of energy conversion wastes.

activities

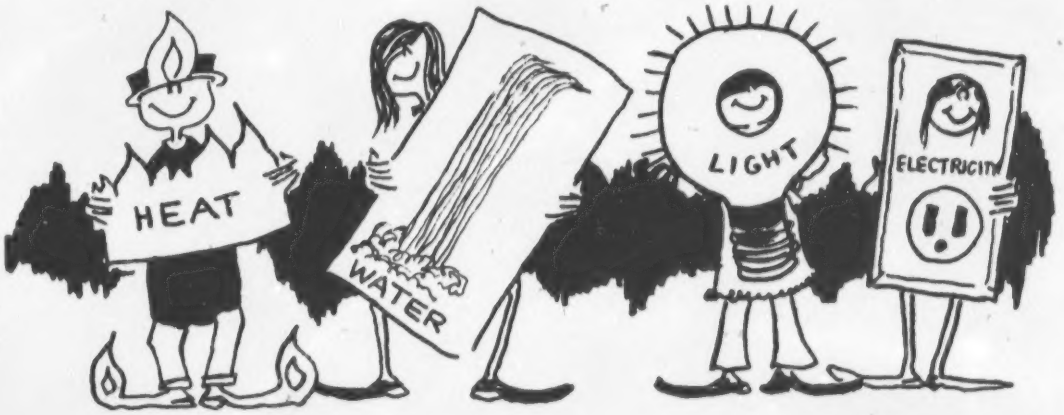
1. List the ethical and practical considerations to be made when disposing of energy conversion wastes.

2. List aesthetically acceptable means of disposing of energy conversion wastes.

3. Have an automotive dealer who has an exhaust-emission analyzer bring it to class and show how it is used. Observe what adjustments are made to the automobile to reduce undesirable emissions. Find out what other accessories not yet fitted to automobiles might reduce undesirable emissions.

4. A nuclear generating plant must have a portion of its used fuel reprocessed every year. This is done at established commercial companies in several states. Recommend means of transportation, waste-disposal methods, security measures and other considerations for the public's protection.

5. List energy-conversion products (heat, gas, water, light, electricity, neutrons, torque noise, work, etc.). Choose one and play a role in which you assume the identity of that product.



Get together with another "product" unlike yourself and decide how you would like to be treated as society disposes of you.

Present conclusions to the class.

6. List the by-products of energy conversion which you find aesthetically objectionable.

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concept: VII - Energy conversion technology has created technological and industrial changes.

conversion

objective: A - The student will identify several pre-industrial societies which made little or limited use of energy conversions.

activities

1. Have the students form groups. Assign each group one of the societies which make limited use of energy conversions. Each group will research the life of the assigned society to determine the types of energy they use. Depict these energy uses in a peep-box, roller show or by role-playing.

2. Research a day in the life of an Eskimo. Write a short play which will depict his activities during the day. Present the play to another group and then discuss what energy conversions were used.

3. Two separate groups of students will research the lives of two pre-industrial societies. After a thorough search, have each group make tools which were used by the society they studied. Do not let either group see the others' artifacts or know what society they have studied. Now have each group present their artifacts and see if the "archaeologists" can unravel what energy sources and conversions were used by the society to produce each item.

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concept: VII - Energy conversion technology has created technological and industrial changes.

conversion

objective: B - The student will be able to relate energy conversion technologies to standard of living.

activities

1. Have the class develop a common definition for "standard of living." Have them discuss differences in the way of life for different standards. They might consider the life of a migrant child, a farm child, an apartment dweller in the city, and a child living in a small American city. Have them relate life-style differences to energy availability/family.

2. Compare standards of living in Haiti, New Zealand, Denmark and the U.S., using a current World Almanac for data regarding power use and gross national products.

   Compare standards of living in several countries using the National Geographic as an information source. Report to the class on life-styles and energy availability, using additional references for the latter. Such reports could be individual or group assignments.

3. Have the class write stories about children in contrasting settings. One has a furnace-heated house, travels by car, watches TV for entertainment, eats ice cream for a snack. The other lives in a palm thatched hut, travels by donkey, surfs for entertainment, eats fresh mangoes for a snack. At some point contrast the energy conversions upon which each depends.

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concept: VII - Energy conversion technology has created technological and industrial changes.

conversion

objective: C - The student will be able to describe how transportation has been affected by energy conversion.

activities

1. Construct a time-line depicting a continuum of man's transportation methods, beginning with floating on a log to, and including, present day methods. Running concurrent with the transportation time-line there will be constructed a time-line showing when each of the major energy sources were used in transportation. Compare.

2. Research the development of the car and depict the developmental changes which were directly related to energy conversions.

3. Research the development of air travel and depict those changes directly related to energy conversions.

4. Research the development of ships and depict those changes directly related to energy conversions.

5. Using bar graphs show the following specific information for ships, plane and train transportation:

   Ships - a. Length of time required to cross the Atlantic Ocean by the Pilgrims.

   b. Length of time required to cross the Atlantic Ocean on a modern cruise ship.

   Plane - a. Length of time required for Lindbergh to cross the Atlantic Ocean on first flight.

   b. Length of time required to cover same distance in modern plane.

   Train - a. Length of time required to complete first trans-America train trip.

   b. Length of time to complete trans-America trip by train today.

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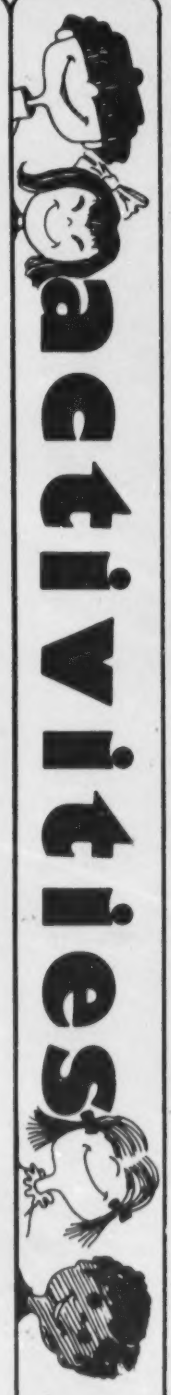
concept: VII - Energy conversion technology has created technological and industrial changes.

conversion

objective: D - The student will be able to identify the ways an industrial society makes use of energy conversion.



activities

1. Construct a model of a hydroelectric installation, depicting the conversion of water power to electrical power.

2. Collect and display as many toys as possible which show conversions of energy (chemical to mechanical, electrical to mechanical, etc.).

3. Draw a simple diagram of the heating system in your home. This should include the primary source of heat (furnace, electric heaters, etc.) and the duct system. Explain where the conversions occur.

4. Draw a diagram of a car's electrical system and explain what conversions take place to make it operate.

5. Disassemble a flashlight and explain how the light works.

6. Visit a dam and power house to learn how energy is converted from water power to electrical energy.

7. Interview the school custodian and have the school's heating system shown and explained to you.

8. Ask each student to compile a list of energy using devices found in and around his home. Compile from these lists a class list. Have the class list each kind of energy used to power the device and the primary source for the energy supply.

9. Given a product (such as a dacron shirt, McDonald hamburger, pop bottle, aluminum can, etc.) trace the conversions needed to produce this product from its original source or sources.

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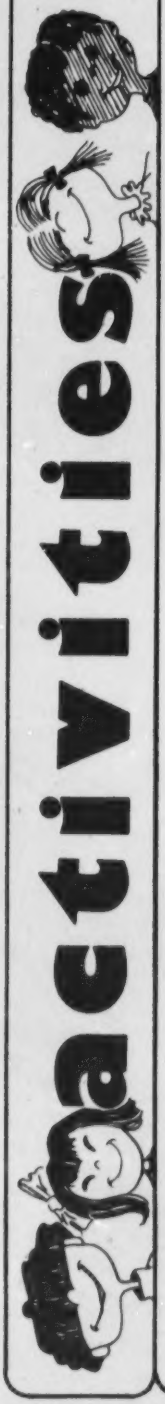
concept: VII - Energy conversion technology has created technological and industrial changes.

conversion

objective: E - The student will be able to relate technological advances in energy conversion with society's industrialization.

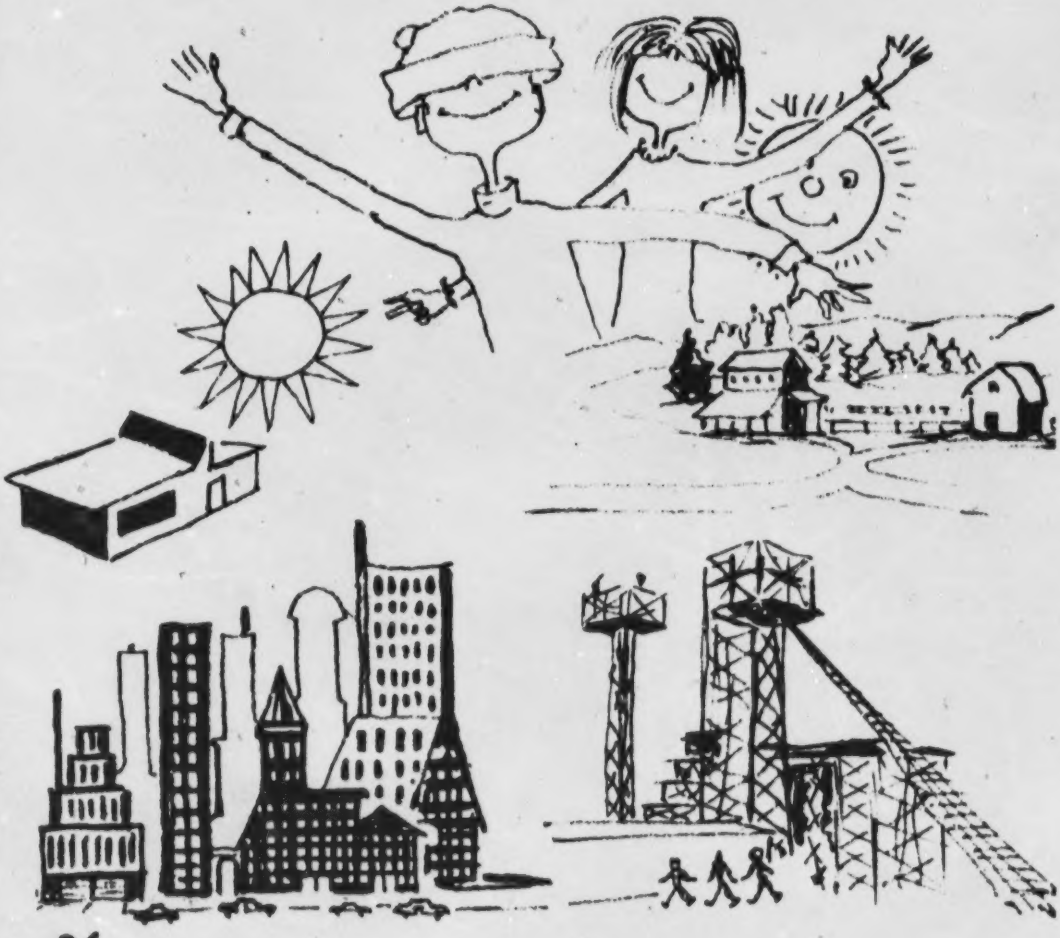


activities

1. Visit a manufacturing plant (any kind or type), list all examples you find of energy conversion, and discuss examples of conservation and waste of energy noted.

2. Having chosen one of the major energy sources used in the world today, go into your own community and photograph those technological advantages made possible by the conversion of this energy source.

3. List the sources and conversions of energy required to publish a message on a clay tablet versus a current newspaper.



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concept: VIII - History can be described in terms of the level of energy conversion technology.

conversion

objective: A - The student will be able to describe the major types of energy conversion used by early man.

activities

1. Reconstruct a day in the life of a nomadic tribe. Consider the activities of men, women, and children. Using a role-play around the evening campfire, have several tribal members recount the day's activities, revealing the energy conversions used. (Early tribes had no beasts of burden. Their lives are approximated by those of Australian aborigines or Malaysian mountain tribes today.)

2. Study the socioeconomic structure of a Hawaiian, pre-missionary village. Study the roles of village members. List the energy conversions employed in the life of the village.

3. Find out what kinds of artifacts are left by nomadic tribes:

   Those of 15,000 years ago.
   Those of North America 500 years ago.
   Those of contemporary Central Asia tribes or contemporary African tribes (Tuareg's).

   Is there a relationship between available energy and development of the arts?

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concept: VIII - History can be described in terms of the level of energy conversion technology.

conversion

objective: B - The student will identify civilizations which used only conversions related to wind, fire, falling water and muscle power.

activities

1. Classical Greece is noted for her artistic productions. How did she achieve the energy status that made possible the development of the arts?

   Compare this with the energy sources/conversions available to the "barbarian" tribes surrounding Greece at that time.

2. What energy conversions were available to the Phoenicians? How did their use affect their civilization? Draw pictures showing activities making use of energy conversions.

3. The Eskimos of North America and the pygmies of Africa are both nomadic tribes. Compare their available energy budgets (what kinds of energy conversions can they make?) and their degrees of civilization (culture?).

4. Read a story or book about the life of a child in another culture (Indian, Eskimo, Japanese village life, African, Mexican village, etc. - depending on availability) and compare your daily life with his/hers. Which of the differences are due to differences in energy-converting capacity?

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concept: VIII - History can be described in terms of the level of energy conversion technology.

conversion

objective: C - The student should be aware of the use of the energy source, coal, that led to the industrial revolution.

activities

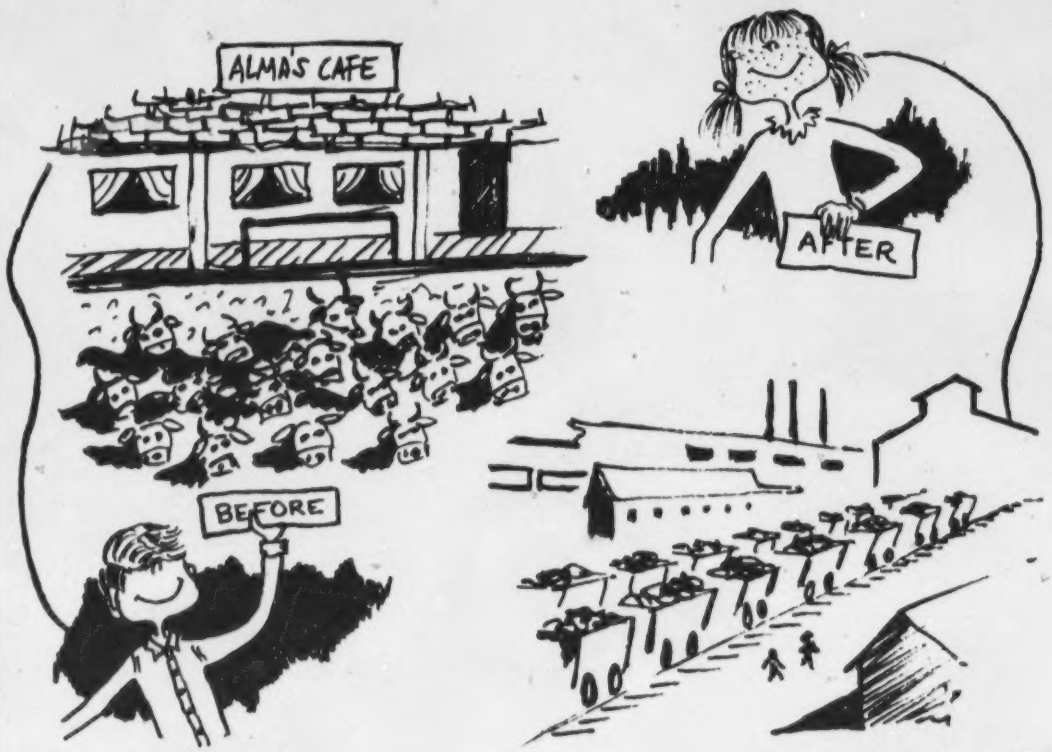
1. What energy conversions were available to the people of central Europe or Great Britain in the 16th and 17th centuries?

   Find out when coal was first mined in England, Germany or the Alsace region. How did this affect the village at that time?

2. Compare life in a frontier town in your state (pre-railroad) with life 25 years after the arrival of the railroad. What part did burning of coal have in the changes that occurred?

   Have the class make a "before and after" mural of a town showing changes that occurred when the railroad came in.

3. If possible get a few lumps of coal to display in the classroom along with pieces of scrap wood. Since both were used to heat homes, have the students find out how changing fuels changed home design and construction.



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concept: VIII - History can be described in terms of the level of energy conversion technology.

conversion

objective: D - The student will explain the chronological patterns evident in the discovery and utilization of fuel conversion processes.

activities

1. Draw pictures of a typical kitchen in the U.S. in 1675, 1775, 1875, 1975.

   Give particular attention to lighting methods.

2. Make a mural for each of the times mentioned in Activity 1, showing collection and delivery of fuel sources for lighting, e.g. chopping and hauling wood (1675); the whaling boat, reduction of the blubber in pots and its delivery to users (1775); gas piped into homes for lighting and coal for the kitchen stove (1875); hydroelectric or coal-fired electric plants, transmission lines, possibly a substation, and finally delivery to a modern home (1975).

3. Beginning with the Apollo space ships, list twelve different current and past methods of transportation and the energy conversion associated with each.

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concept: IX - Employment opportunities are created or destroyed in the evolution of conversion technologies.

conversion

objective: A - The student will be able to compare the jobs created and the jobs replaced by the advent of oil conversion.

activities

1. Compare jobs required to man sailing ships with those needed on motor-powered ships.
2. Identify the kinds of jobs which evaporated when gas powered transportation was introduced.
3. Identify jobs which developed with the advent of gas-powered transporation.
4. When oil and natural gas replaced coal and sawdust for home heating, two manual labor activities were eliminated. Name them.
5. The conversion of fossil fuels to synthetic products caused the decline of the natural rubber industry. Research this decline and depict the jobs lost.
6. The city council is meeting to hear the reasons for replacing electric trolleys with diesel buses. Prepare a speech which will examine the benefits of each side.

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concept: IX - Employment opportunities are created or destroyed in the evolution of conversion technologies.

conversion

objective: B - The student will be able to describe those jobs resulting from the creating of electrical power and those replaced by this activity.

activities

1. Compare jobs available in a city using all electric utilities with jobs available in a city having coal, gas or oil-fired utilities.

2. List the jobs created in a community by the building of:

   a. a coal-fired electric power plant
   b. an oil-fired electric power plant
   c. a gas-fired electric power plant
   d. a nuclear-fueled electric power plant

   List the jobs displaced by such construction.

3. Report on the kinds of employment in electric-powered industries that have no counterpart in others.

4. Research the jobs which were displaced when the major source of lighting became electricity rather than gas.

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concept: IX - Employment opportunities are created or destroyed in the evolution of conversion technologies.

conversion

objective: C - The student will be able to identify those job opportunities which were created and those which were reduced when coal displaced wood as a major energy source.

activities

1. Speculate on the type of job you think was most prevalent when wood fuel was a major source of our nation's energy. Consider this same problem regarding coal.

2. Assume the role of someone supporting the conversion from wood to coal. Prepare an argument to present to the community supporting your point of view. Remember to include all those things which will benefit your community, i.e., new industries, new jobs, additional income, etc.

3. Assume the role of someone who will be displaced by the conversion to coal. Prepare an argument to support your point of view. Remember to include the loss of jobs, revenue, industries, population and what coal will do to the environment.

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concept: IX - Employment opportunities are created or destroyed in the evolution of conversion technologies.

conversion

objective: D - The student will describe career opportunities which have arisen in terms of the nuclear power industry.

activities

1. Describe the major differences between research and development of uranium as a fuel and research and development of fossil fuels.

2. Request from the personnel offices of a nuclear power plant and a fossil-fueled power plant the numbers of employees in each classification of work. Compare the needs for scientific expertise and discuss the reasons therefore.

3. Compare the similar and dissimilar technical skills required to construct a nuclear power plant, a fossil plant and a hydroelectric dam.

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concept: IX - Employment opportunities are created or destroyed in the evolution of conversion technologies.

conversion

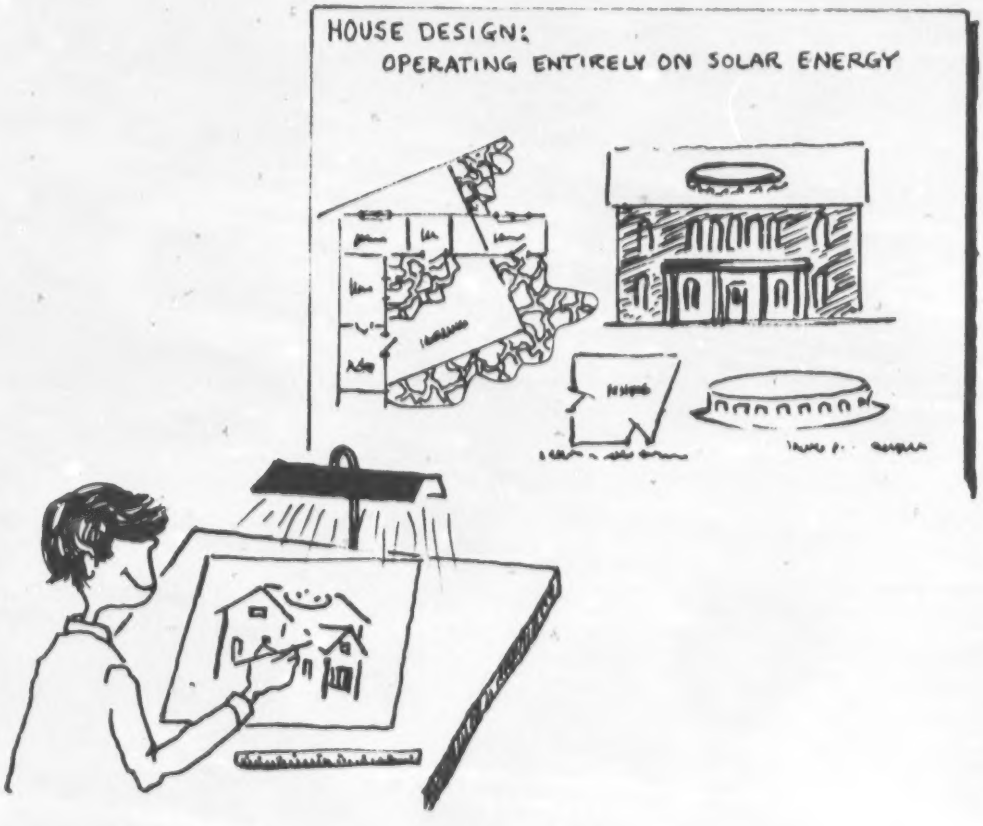
objective: E - The student will be able to list jobs which will be created as man converts the sun's energy to industrial uses.

activities

1. Suppose we were able to convert the sun's energy directly. List the new types of jobs that would be available. Which types of existing jobs do you think would be eliminated or reduced? Give reasons.

2. Contrast an individual who builds a cold frame to utilize the sun's energy to heat the planting area, with the designers, builders, and installers of a commercial solar hot water heating system for a commercial building.

3. You are an architect. Design a house which runs entirely on solar energy. What people and their skills will you need in order to build this house?



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